are only slightly oblique, and the obliquity is outwards in front. The lines on the elytra are more deeply engraved.

This may be a sport of *H. quadrilineatum*; but the presence of the two deep dorsal lines on the thorax warrants one at least in regarding it as distinct until a greater series of specimens enables us to see whether there are any passages between the one and the other or not.

I have called it after my friend Mr. Frederick Smith. I have only seen one specimen.

5. *Hectarthrum simplex.*

H. quadrilineato affinis; elytris linea suturali et marginali apice conjunctis et lineis duabus medio.

Long. 3½–4½ lin., lat. ¾–1 lin.

Similar to *H. quadrilineatum*; but it has not the line or stria on the elytra next the sutural stria; the sutural stria is further from the suture than in it, leaving a wider sutural space. It might be called *trilineatum*, if we were not to reckon the marginal stria, as *H. quadrilineatum* is only four-lined if we do not reckon the marginal stria; reckoning that stria, it is five-lined. Here there is first the sutural stria, next two close on the middle, and lastly the marginal stria out of sight round the corner.

The antennæ of the male are remarkably and gradually thickened in the middle—a character not peculiar to it, but present in other species.

[To be continued.]

XLIX.—*On the Temperature of Geological Periods, from indications derived from the observation of Fossil Plants.* By the Count Gaston de Saporta.

[Concluded from p. 282.]

§ 2. *Examination of the Genera peculiar to the Northern Temperate Zone observed in the Ancient Floras.*

The genera to the investigation of which I now advance are for the most part those which we have still before our eyes. It is to them that our indigenous vegetation owes its character: they seem to be adapted to the conditions of our temperature; and consequently it would appear that they must have commenced at the period when this was definitively established. I shall show that this is not the case, and that, from causes which we can as yet only appreciate very imperfectly, their existence in the past ascends far beyond the time when the European climate became similar to what it is at present.

The following is an enumeration of these genera, of course restricted to the principal ones—that is to say, to those which play an important part in the general vegetation of the northern temperate zone and are at the same time most frequently observed in the fossil state in several successive stages:—

Alnus, Tournef.
Betula, Tournef.
Ostrya, Mich.
Carpinus, Tournef.
Corylus, Tournef.
Quercus, Linn.
Fagus, Tournef.
Castanea, Tournef.
Ulmus, Linn.
Celtis, Tournef.
Platanus, Linn.
Populus, Tournef.
Salix, Tournef.
Fraxinus, Linn.
Hedera, Linn.
Cornus, Tournef.
Liquidambar, Linn.
Liriodendron, Linn.
Acer, Linn.
Juglans, Linn.
Cratægus, Linn.
Cercis, Linn.

This list includes twenty-two genera, of which eighteen still grow naturally in Europe; three (*Platanus, Liquidambar, Juglans*), without being spontaneous in Europe, inhabit the neighbouring parts of Asia as well as North America; one only (*Liriodendron*) is no longer met with except in the New World. But these last only quitted our soil at an epoch very nearly approaching our own; so that, by going a little backward, one might say that all these genera equally characterize the northern temperate zone, the limits of which they overstep only exceptionally*, and solely by means of certain mountainous regions in which altitude compensates the climate. As regards their polar limits these genera show great diversities. The willows and birches advance furthest towards the north, since they reach Iceland, but certainly with repent species. The oak does not pass Stockholm, with a mean temperature of 5° C. (= 41° F.); the ash stops at Gothenburg, with 7°·9 C. (= 46°·2 F.). The chestnut and the plane do not go so far. But these differences depend rather on the inherent aptitudes of the species than even on those of the genus, especially in the frequent cases where the latter is represented by a small number of species, or even by a single one; the area of the genus then depends upon that of the species, and is confounded with it. Whatever be the nature of these diversities, they may and must relate to anterior causes, and especially to those which we now proceed to study.

In ascending the course of ages we shall pass through the same periods that we have just traversed, but inversely, and commencing with the most recent. The eighth of our horizons,

* The genus *Fagus* reappears in the southern hemisphere, but in forms sufficiently distinct from those of the boreal zone to constitute another type.

formed by the quaternary deposits, furnishes the following list, which is nearly complete:—

Alnus glutinosa, Linn. Travertins of Montpellier.
Betula prisca, Ett. Tuscan Travertins.
Carpinus betulus, Linn. Cannstadt.
Corylus avellana, Linn. Travertins of Provence.
Quercus pubescens, Wild. Travertins of Provence.
Fagus sylvatica, Linn. Tuscan Travertins.
Ulmus campestris, Linn. Travertins of Tuscany and Provence.
Celtis australis, Linn. Travertins of Provence.
Populus alba, Linn. Ditto.
Salix viminalis, Linn. Ditto.
—— *caprea*, Linn. Ditto.
Platanus aceroides, Göpp. Tuscan Travertins.
Fraxinus ornus, Linn. Ditto.
Hedera helix, Linn. Travertins of Tuscany and Provence.
Cornus sanguinea, Linn. Ditto.
Liquidambar europæum, Al. Br. Travertins of Tuscany.
Acer opulifolium, Linn. Travertins of Tuscany and Provence.
Juglans graviæfolia, Gaud. Travertins of Tuscany.
—— *regia*, Linn. Travertins of Provence.
Cratægus oxyacantha, Linn. Ditto.
Cercis siliquastrum, Linn. Travertins of Tuscany and Provence.

In this list only a very small number of genera are wanting. It must even be remarked that *Ostrya* is difficult to distinguish from the hornbeam without the fruits, and that the chestnut, frequenting siliceous soils, must have kept at a distance from the localities where the travertins were formed. On the other hand, among the genera which have since become extra-European, *Juglans*, *Liquidambar*, and *Platanus* show themselves in proof of their late elimination; the genus *Liriodendron* is the only one that does not make its appearance, as, no doubt, it had already disappeared from Europe.

The seventh horizon, the Pliocene, is richly represented by the floras of Schossnitz, Gleichenberg, Senegaglia, and the Val d'Arno; it furnishes the following list, which includes only the most prominent species of the period:—

Alnus Kefersteinii, Göpp. Tuscany.
Betula macrophylla, Göpp. Schossnitz.
—— *prisca*, Ett. Tuscany.
Ostrya Prasili, Ung. Gleichenberg.
Carpinus pyramidalis, Göpp. Schossnitz, Tuscany.
Corylus Wickenburgi, Ung. Gleichenberg.
Quercus drymeja, Ung. Tuscany.
—— *lucumonum*, Gaud. Tuscany.
—— *mediterranea*, Ung. Tuscany.
Fagus Deucalionis, Ung. Senegaglia.
—— *attenuata*, Göpp. Schossnitz.
Castanea Kubinyi, Kor. Tuscany.
Ulmus Wimmeriana, Göpp. Schossnitz.

Ulmus Bronnii, Ung. Tuscany.
Populus balzamoides, Göpp. Schossnitz, Tuscany.
—— *leucophylla*, Ung. Tuscany.
Salix varians, Göpp. Schossnitz, Tuscany.
Platanus aceroides, Göpp. Schossnitz, Tuscany.
Liquidambar europæum, Al. Br. Schossnitz, Tuscany.
Fraxinus prædicta, Heer. Senegaglia.
Cornus Buchii, Heer. Tuscany.
Hedera Strozzii, Gaud. Tuscany.
Liriodendron Procaccinii, Ung. Senegaglia.
Acer Penzianum, Gaud. Tuscany.
—— *Sismondæ*, Gaud. Tuscany.
Juglans Strozziana, Gaud. Tuscany.
—— *nux-tauriensis*, Brong. Tuscany.
Cratægus oxyacanthoides, Göpp. Schossnitz.

All the genera of our list consequently existed in Pliocene Europe, and most of them were represented by more numerous and varied species than at the present day.

The following horizon, the sixth, which includes the rich vegetation of Œningen, that of Bilin, Parschlug, &c., brings but few changes into our list:—

Alnus Kefersteinii, Göpp. Bilin.
—— *Œningensis*, Heer. Œningen.
—— *gracilis*, Ung. Bilin.
Betula Ungeri, Andr. Œningen.
—— *Weisii*, Heer. Œningen.
Ostrya Œningensis, Heer. Œningen.
Carpinus Œningensis, Göpp. Œningen.
—— *pyramidalis*, Göpp. Œningen.
Corylus insignis, Heer. Lausanne.
Quercus neriifolia, Al. Br. Œningen.
—— *drymeja*, Ung. Parschlug.
—— *elæna*, Ung. Œningen, Parschlug.
Fagus Feroniæ, Ung. Bilin.
—— *Deucalionis*, Ung. Parschlug.
—— *castaneæfolia*, Ung. Styria.
Ulmus plurinervia, Ung. Parschlug.
—— *longifolia*, Ung. Bilin.
—— *Braunii*, Heer. Œningen.
—— *minuta*, Göpp. Œningen.
Celtis Japeti, Ung. Parschlug.
Populus latior, Al. Br. Œningen.
—— *mutabilis*, Heer. Œningen.
—— *heliadum*, Ung. Œningen, Parschlug.
Salix varians, Göpp. Œningen.
—— *Lavateri*, Heer. Œningen.
Platanus aceroides, Göpp. Œningen, Schrotzberg.
Liquidambar europæum, Al. Br. Œningen, &c.
Fraxinus prædicta, Heer. Œningen.
—— *deleta*, Heer. Œningen.
Cornus Buchii, Heer. Œningen.
Hedera Kargii, Al. Br. Œningen.
Liriodendron Procaccinii, Ung. Stradella.

Acer trilobatum, Al. Br. Œningen, Parschlug, &c.
—— *decipiens*, Al. Br. Œningen.
—— *otopteryx*, Göpp. Œningen, Parschlug.
Juglans acuminata, Al. Br. Œningen, Parschlug.
—— *bilinica*, Ung. Œningen, Bilin.
Cratægus oxyacanthoides, Göpp. Œningen.
Cercis cyclophylla, Al. Br. Œningen.

Most of these genera seem to have attained their apogee in Europe, and the more important of them unite upon the same spot forms now scattered over very different countries. This affluence begins to decrease when we quit this horizon to ascend towards the preceding one or that of the lower Miocene.

This is the fifth of our series: it includes the floras of Manosque in Provence, Ménat in Auvergne, Brognon near Dijon, Monod, Hohe-Rhonen, and Eriz in Switzerland, the plants of the Surturbrand of Iceland and of Atanekerdluk in North Greenland*, those of the Baltic amber and of several other localities.

The following is an exact list of the European genera the existence of which is proved by means of these various deposits:—

Alnus nostratum, Ung. Manosque, Monod.
—— *Kefersteinii*, Göpp. Iceland, Monod.
Betula elliptica, Sap. Manosque.
—— *Blancheti*, Heer. Monod.
—— *macroptera*, Göpp. Iceland.
—— *prisca*, Ett. Iceland.
Ostrya Œningensis, Ung. Manosque.
—— *Walkeri*, Heer. Greenland.
Carpinus grandis, Ung. Manosque, Monod.
Corylus insignis, Heer. Hohe-Rhonen.
—— *Macquarii*, Heer, Ménat, Iceland, Greenland, Hohe-Rhonen.
Quercus Olafseni, Heer. Iceland, Greenland.
—— *elæna*, Ung. Monod.
—— *drymeja*, Ung. Greenland.
Fagus pristina, Sap. Manosque.
—— *Deucalionis*, Ung. Greenland.
—— *castaneæfolia*, Ung. Greenland.
Ulmus Fischeri, Heer. Monod.
—— *diptera*, Steenstr. Iceland.
—— *discerpta*, Sap. Manosque.
Populus Gaudini, Heer. Monod.
—— *Richardsoni*, Heer. Iceland, Greenland.
—— *Zaddachi*, Heer. Greenland, Amber.
Salix macrophylla, Heer. Eriz, Iceland.
—— *Gaudini*, Fisch. Monod.
Platanus aceroides, Göpp. Iceland, Greenland.
Fraxinus inæqualis, Heer. Manosque, Monod.
—— *denticulata*, Heer. Greenland.

* See 'Ueber den versteinerten Wald von Atanekerdluk in Nord-Groenland,' by Prof. Oswald Heer.

Liquidambar europæum, Al. Br. Horw (Switzerland), Sagor (Germany).
Cornus orbifera, Heer. Monod.
—— *Studeri*, Heer. Monod.
Hedera Maclurei, Heer. Greenland.
Liriodendron Procaccinii, Ung. Eriz, Iceland.
Acer trilobatum, Al. Br. Manosque, Monod.
—— *Ruminianum*, Heer. Manosque, Monod.
—— *otopteryx*, Göpp. Iceland.
Juglans bilinica, Ung. Manosque, Monod, Iceland.
—— *acuminata*, Al. Br. Greenland.
Cratægus tenuifolia, Sap. Clay of the Marseilles basin.
Cercis Tournouëri, Sap. Brognon.

The list is still complete; but some of these genera will no longer appear. Such are *Platanus*, *Fraxinus*, and *Liquidambar*; and it is to be remarked that these are not the most northern forms. The *Platani* and Liquidambars prefer the warm temperate zone—a circumstance which explains their exclusion from Europe by the effects of the glacial period. Here the first known traces of these genera make their appearance in the Arctic regions, which then possessed species in common with Europe, and which, although warmer than at present, were nevertheless subject to the influence of latitude, since the species with deciduous leaves already predominated there, and several of them only spread at a later period over the middle of Europe, such as *Betula prisca* and *macrophylla*, *Platanus aceroides* and *Acer otopteryx*—a phenomenon still obscure, but of great interest, if we succeed in ascertaining it with precision.

In approaching the Tongrian or fourth horizon, a decisive period in the question under examination, I find it preferable, from the rather complex affinities of the floras which I refer to it, to divide them into two partial horizons—one, more recent, nearly approaching that which we have just quitted, the other including the Tongrian properly so called. On the former I place Radoboj and Armissan (very rich localities, which present a remarkable correspondence), and we thus obtain the following list:—

Alnus microdonta, Sap. Armissan.
Betula dryadum, Brong. Armissan.
—— *Ungeri*, Andr. Radoboj.
Ostrya atlantidis, Ung. Radoboj, Armissan.
Carpinus grandis, Ung. Radoboj.
Quercus magnoliæformis, Sap. Armissan.
—— *oligodonta*, Sap. Armissan.
—— *sinuatiloba*, Sap. Armissan.
Castanea palæopumila, Andr. Armissan.
Fagus atlantica, Ung. Radoboj.
Celtis primigenia, Sap. Armissan.
Ulmus Bronnii, Ung. Armissan.
—— *prisca*, Ung. Radoboj.

Ulmus bicornis, Ung. Radoboj.
Populus palæomelas, Sap. Armissan.
—— *salerophylla*, Sap. Armissan.
—— *heliadum*, Ung. Radoboj.
Salix linearis, Sap. Armissan.
Acer narbonense, Sap. Armissan.
—— *pseudo-campestre*, Ung. Armissan.
—— *megalopteryx*, Ung. Radoboj.
—— *campylopteryx*, Ung. Radoboj.
Juglans radobojana, Ung. Radoboj.
—— *basilica*, Ung. Radoboj.
Cercis radobojana, Ung. Radoboj.

Thus at the level of Armissan and Radoboj the group of European genera no longer appears so complete as in the more recent stages; nevertheless the principal genera are still at least as richly represented as in the present epoch, and the species, generally founded on prominent organs, leave no room for any uncertainty as to their determination.

The change becomes more sensible on advancing towards the Tongrian properly so called, represented by the floras of Saint-Jean-de-Garguier near Marseilles, of Saint-Zacharie (Var), and of Haering and Sotzka in Austria. The following is this new list:—

Alnus prisca, Sap. St.-Zacharie.
Betula ulmacea, Sap. St.-Zacharie.
—— *pulchella*, Sap. Marseilles.
Ostrya tenerrima, Sap. St.-Zacharie.
Carpinus cuspidata, Sap. St.-Zacharie.
Quercus lonchitis, Ung. Sotzka.
—— *elæna*, Ung. St.-Zacharie.
Castanea atavia, Ung. Sotzka.
Ulmus primæva, Sap. St.-Zacharie.
Populus leuce, Ung. Sotzka.
Acer primævum, Sap. St.-Zacharie.
Juglans elænioides, Ung. Sotzka.
Cratægus palæacantha, Sap. St.-Zacharie.

The genera which no longer recur beneath this horizon are *Corylus*, *Fagus*, and *Celtis*. The absence of the others remains doubtful, more especially as we find indications of them at a far more distant period. Moreover it would be wrong to conclude, from the absence of a genus, its absolute non-existence; we may assume that in many cases its subordinate position placed an insurmountable obstacle to its passage to the fossil state. What is certain is the existence of the genera which figure in our list at a period when the vegetation was still endowed with a well-marked tropical and Australian character. Several of these genera, especially *Alnus*, *Betula*, *Carpinus*, *Ostrya*, *Acer*, and *Cratægus*, are represented by forms the analogy of which with

those corresponding to them in the present state of things is truly surprising.

The third horizon, composed chiefly of the flora of the gypsum of Aix, brings out this phenomenon still more strongly. In it we find the following European genera, taking into account the most recent observations:—

Alnus antiquorum, Sap.
Betula gypsicola, Sap.
Ostrya humilis, Sap.
Quercus salicina, Sap.
Ulmus plurinervia, Sap.
Populus Heerii, Sap.
Cornus, sp.?
Hedera, sp.
Acer ampelophyllum, Sap.
Cratægus nobilis, Sap.
Cercis antiqua, Sap.

More than half the genera that figured in my list appear to have disappeared in the period extending from the Middle Miocene to the Upper Eocene. Those which remain are represented in each locality only by a very small number of species, or even by a single one. Most of these species, however, are very well characterized, and known by their fruits as well as by their leaves. The fruit of *Ulmus plurinervia*, lately found by M. Marion, indicates a species very nearly allied to our *U. campestris*. The leaves of *Cratægus nobilis* are hardly to be distinguished from those of our hawthorn. *Cercis antiqua* differs but little from our *C. siliquastrum*; but *Betula gypsicola*, from the examination of its leaf, would resemble the smallest forms of its genus; whilst *Populus Heerii* resembles *P. euphratica*, Oliv., in its fruit, and *P. laurifolia*, Leb., in its leaf. There is therefore a very considerable diversity in the mutual affinity of these types with those of the present day. In general they are remarkable rather by a sort of stunted condition of the foliaceous appendages (which leads us to ascribe to them only a moderate size) than by their differential characters, which present nothing very striking.

I had formerly thought that the flora of Aix was really the starting-point of that boreal group which we have seen reappearing with so much persistency at all the steps of the series of stages; and what confirmed me in this notion was, that the previous stages did not contain any very distinct traces of it; but during the last few months my profound study of the plants from the celebrated locality of Sézanne, belonging to the stage of the sands of Rilly, has compelled me to abandon this opinion.

In fact, in this the oldest known flora of the Tertiary epoch, I have observed, in the midst of a multitude of Dicotyledons of exotic physiognomy, and very difficult of determination, traces of a portion of the European genera the progress of which we have just followed; and among these I have even met with some

which appeared to be absent from the last floras that we have passed in review. The following would be the enumeration of these genera, assuming as well founded presumptions suggested by a nearly definitive examination:—

Alnus: two species, one modelled on the type of *Alnus cordifolia*, Ten., and the other on that of *A. glutinosa*, Gaertn.
Betula: a species analogous to *B. lenta*, Linn.
Dryophyllum, Deb.: three species analogous to certain species of *Quercus*, *Castanea*, and *Castanopsis*.
Ulmus: a very distinctly characterized species.
Populus: a species analogous to *P. heterophylla*, Desf.
Salix: two species analogous to *Salix fragilis*, Linn., and *amygdalina*, Linn.
Hedera: a species reproducing the type of *H. helix*, var. *hibernica*.
Cornus: a species analogous to *C. officinalis*, Lieb.
Juglandites: several species, one of them not far from *J. regia*.

This group is remarkable for its conformity with the preceding data. Most of the genera the existence of which in the last place was ascertained reappear; and we remark no alteration in their physiognomy, except that which results from the aspect of the vegetation of which they form a part—that is to say, a development of the foliaceous limb, peculiar to most of the plants of Sézanne. It appears from their examination that the period at which they lived, or perhaps only the locality where they grew, favoured in them this expansion of the appendicular organs, which contrasts so strongly with the stunted and coriaceous forms of the period of the gypsum of Aix. However this may be, and notwithstanding the doubts which may still attach to some of the determinations indicated by me, most of these genera appear to me at present to be legitimately determined, so much do they approach the corresponding existing types. I will indicate *Alnus*, *Ulmus*, *Salix*, *Populus*, *Hedera*, and *Cornus* as those the unexpected existence of which at so distant a period appears to me best demonstrated.

Still further on, in the Upper Cretaceous period, the existence of European genera has not been ascertained, except in a very vague manner. The investigations are too recent and the observations too rare to inspire complete confidence. I think, therefore, that the *Carpinites*, *Acerites*, and *Juglandites* of this period must be subjected to a fresh examination before they can be accepted as corresponding with types really allied to those from which their denomination has been derived. Nevertheless I have lately had in my hands some impressions from the Upper Chalk of Halden, in Westphalia, resembling the genus *Alnus* in several details of form and venation; the *Dryophylla* of Aix-la-Chapelle have too close analogies with the Cupuliferæ to be quite foreign to that group; and we must also mention the

Liriodendron Meckii, Heer, indicated by Dr. Heer in the Upper Chalk of Nebraska, associated with *Magnoliæ** and other Dicotyledons, among which the learned professor of Zurich thought he could recognize the genera *Populus*, *Salix*, and *Platanus*, although too doubtfully to allow their presence to be positively affirmed.

We must therefore stop at this latter limit and close this long examination. Leaving all theory out of the question, it appears, from the combined progress of the tropical and European types, that these two categories have coexisted for a long time without eliminating each other, but simply in juxtaposition. The time during which this juxtaposition lasted was much longer than has hitherto been supposed. It extends from the extreme base of the Tertiary series nearly to the close of the Swiss Mollasse. In fact it is only at this epoch that the tropical types decline and are gradually eliminated by the genera which have remained proper to the boreal zone, and of which the preponderance increases in the same proportion. Between these limits the two groups live associated together without any great variation in the physiognomy and relative proportions of the indigenous group, although its part must sometimes have diminished to such an extent as to deprive us of the traces of its existence, or at least to render them very rare.

III.

All that is necessary now is to sum up the preceding observations, so as to draw general conclusions from them.

If we consider plants alone, geological time may be divided pretty naturally into a certain number of great phytological periods.

In the first and most distant we cannot indicate with certainty any of the existing genera: Dicotyledons and Monocotyledons are absent; we observe exclusively Vascular Cryptogamia and Gymnospermia; a portion only of these plants enter into still existing families; the indications derived from the observation of these seem to announce the existence of a warm, humid, equable climate, subjected to uniform conditions all over the globe.

In the second period, which includes the Triassic, the Jurassic, and a part of the Cretaceous epochs, the character of the vegetation changes sensibly. We can already indicate a small number of genera identical with those of the existing world; the

* The persistence of the characteristic types of the present temperate regions in the secondary formations is also attested by cones of the genus *Cedrus*, in admirable preservation, observed by M. Heer in the chalk of Moletein in Moravia.

plants may be classed in still existing families; but the Dicotyledons are still absent, and the Monocotyledons scarcely make their appearance. The appreciable indices show the existence of a temperature approaching that which prevails in southern countries in the vicinity of the tropics, between 20° and 30° S. lat. This temperature may be estimated at a mean of 20° C. (=68° F.).

The Cretaceous series, starting from its middle stages, constitutes a third period, resembling the preceding in certain respects, by the persistence of the same genera. Nevertheless the Cycadeæ begin to decline, the Pandaneæ and the Palms are developed, and, lastly, the Dicotyledons make their appearance and multiply rapidly.

The signification, however, that must be attached to these different evolutions is still somewhat ambiguous, since plainly tropical types, such as the Pandaneæ, are thenceforward associated with subtropical Australian types, such as the Proteaceæ and *Araucaria*, boreal types, such as *Sequoia* and *Cedrus*, or cosmopolite types, such as the Myriceæ. All these indications combined seem to denote a tropical temperature with no excess, probably variable according to the seasons in a degree which it is difficult to appreciate.

The inferior Tertiary, including the Tongrian, forms a new period, during which the genera which have since continued characteristic of the boreal zone appear in juxtaposition with genera with tropical or subtropical affinities; but the former remain stationary or subordinate, whilst the latter do not cease to develope themselves and maintain their preponderance. According to all indications, the temperature was then that of the present tropical regions; but the climate (that is to say, the proportion of humidity and the distribution and economy of the seasons) must have varied several times—changes reflected by the vegetation, which differs from stage to stage, whilst that of each stage presents a general resemblance. It is by this means that we may explain the alternate predominance and exclusion of the Proteaceæ, and the successive enlargement and diminution of the leaf, through the Suessonian, Eocene, and Tongrian stages.

The Miocene, or Middle Tertiary, constitutes by itself a fifth period, during which the vegetation of ancient Europe attains its highest degree of development. This state of things is prolonged up to the level of Œningen, but without remaining stationary: the types characteristic of our zone are constantly being developed and completed, as well as the subtropical types; the tropical and Australian types, on the contrary, tend to depart and disappear.

The Pliocene age constitutes a last period, during which the

tropical types finally disappeared, the subtropical ones still persisting; but the predominance from that time attained by the European types tends to become more and more exclusive, while the temperature, following the same movement, gradually decreases so as to become more and more like that which we now have.

Thus, to sum up, the temperature has formerly undergone oscillations which it is difficult to define; but, notwithstanding these variations, it preserved a degree of elevation nearly equal to that which now exists under the tropics, until after the middle of the Tertiary period.

It is only after that point (that is to say, about the epoch at which the Swiss Mollasse was deposited) that it began to decline; and yet, long before this age, continual transformations had taken place in the midst of the vegetation of ancient Europe—changes correlative with a progress which may be spoken of as regular through all the periods. We must therefore be careful not to confound the effects of temperature with those of organic evolution, which brought about the first appearance and then the development of the various types of plants.

The two phenomena are far from standing towards each other in the relation of effect and cause. At the utmost the modifications of temperature have constituted occasional circumstances with which certain evolutions may have corresponded. It is impossible at this distance to conjecture the nature of the circumstances which must have occurred; but in assuming the presence of certain truly tropical genera as a proof of elevation of temperature, we see that the first ascertained types only partially correspond with this supposed elevation; whilst, on the other hand, the appearance of the European types by no means coincides with any lowering of the primitive temperature. We see also that these types, or at least several of them, were already fixed at a very distant epoch, and have not since varied, even as regards the consistence of the foliaceous tissue, which must have been membranous and caducous at that time as at present.

With regard to the progress proper to all these genera, we must distinguish two kinds of evolution,—one peculiar to such genera as *Alnus*, *Carpinus*, and *Ulmus*, of which the physiognomy is uniform, and which include a rather small number of species. The species of these genera, similar in time to what they are now in space, occur from their origin with their present physiognomy; they are only scarcely diversified impressions of a not very variable type. The other kind of evolution applies to more numerous and heterogeneous groups, which, like *Quercus*, include species of very diverse forms and aptitudes. Here the

evolution has rather been successive; that is to say, certain sections have preceded others which have come more slowly upon our ground: this more or less regular progress consists in a sort of elaboration in which the notion of specific individuality is much weakened. In the genera with a fixed physiognomy this notion disappears still more; so that in vegetable palæontology everything concurs to increase the importance of the type to the detriment of the species, since the former does not cease to manifest its action during a very long period, whilst the species issuing from this type resemble each other, notwithstanding the diversity of the epochs to which they belong, to such a degree that they are sometimes not very distinguishable.

In Palæozoic times the heat may have been greater than it is now even under the equator; nevertheless we have no direct proof of this by means of plants, since the number of arborescent ferns has been found to be less than was at first supposed. We know only that the temperature of the terrestrial surface was then more uniform, more equable than at present; and that the polar regions themselves, participating in this uniformity, possessed plants like those of other countries.

This is a noteworthy fact, but one the importance of which must not be exaggerated, since the same fact existed again towards the Miocene period. The polar forms of the Carboniferous formation, which, in part at least, are specifically distinct from those of other contemporaneous regions, may have been capable of supporting a temperature relatively colder than that which governed the coal-vegetation of the rest of the world. It is therefore by no means impossible to conceive a certain gradation of climates in this primitive period.

The absence of any classes of plants except the Cryptogamia and the Gymnospermia cannot be an argument in favour of an excessive elevation of temperature during this primitive age, since the organic development from which the vegetable kingdom has issued has operated in a gradual and determinate order, which, so to speak, implies the anteriority of certain classes. This anteriority must have depended at least as much on the mode of evolution proper to the vegetable kingdom as on the degree of elevation of the initial temperature. The most we can say is, that, organisms having been in all times adapted to the external circumstances in the midst of which they are produced, we may deduce, by analogy, from the examination of these organisms the determination of the circumstances themselves; and it is in fact at this point that we must stop.

Whatever may have been the initial elevation of the temperature, the data that we obtain from fossil botany for the Coal period are reduced to the following, namely, its greater uniformity, its

warm humidity, the probable density of the atmosphere, and a much less influence of latitude. It is for the stratigraphical geologist to determine whether, as is generally admitted, the internal heat may have still acted efficaciously in increasing the temperature through the already thick crust of the rind of the earth, and whether thermal springs could rise, as they subsequently did, through beds much less folded and fractured, in rocks for the most part not stratified, and in the absence of any considerable elevations. Lastly, the initial temperature must have undergone climatic combinations very different from those of the succeeding epoch, since the elimination of most of the types of this first vegetation was rapid after a certain point of time, and many of them disappeared for ever.

The temperature of the secondary periods (still consulting only the indications furnished by plants) cannot have exceeded, and perhaps did not even equal, that of our present intertropical regions. The types of this period which still exist (*Equisetum*, *Araucaria*, *Encephalartos*) tend to prove this. In any case the climate was differently constituted, and the ground more broken up than before, since the Cycadeæ, which now predominated, are not plants of the marsh and riverside, but prefer to inhabit slopes and ridges.

The first appearance and development of the Angiospermia, and especially of the Dicotyledons, must have been the result of an organic evolution; it is impossible for us to conjecture whether the state of the temperature contributed to it at all. Great organic changes took place during the second half of the Cretaceous period; and the result of these changes, perhaps combined with the emergence of land, which then took place on a large scale, may have been to favour the origination of new types at the expense of the old ones. This movement is still more strongly marked at the commencement of Tertiary time, when most of the existing groups, or at least those which include the ligneous plants, appear endowed with the same characters which still distinguish them, and which have not since varied in anything essential. If the temperature seems to have remained stationary, the climate, or the external conditions of this temperature, appears to have changed repeatedly. Hence arise very sensible variations, by the predominance or exclusion of certain groups and the characteristic physiognomy of certain floras. Nevertheless these exclusions could not be absolute, but relative to certain regions or to the localities capable of furnishing us with impressions. The group of the Proteaceæ, developed in the first place during the Upper Cretaceous period, and effaced during the deposition of the Suessonian, reappears afresh after this epoch, and presents itself as far as the Miocene.

This intermittence is one of the principal phases of the alternations which we remark in the ancient vegetation, without being able yet to define them exactly. Nothing, I again repeat, indicates that the temperature was then sensibly lowered; but it is remarkable that the European genera seem to have been favoured in their origin by the very circumstances which were unfavourable to the Australian types, and especially to the Proteaceæ*. The latter, indeed, like the Cycadeæ themselves, as is proved by the presence in the Miocene of *Zamites epibius*, Sap. (Bonnieux), *Lomatites aquensis*, Sap. (Bonnieux, Manosque), and *Grevillea anisoloba*, Brong. (Koumi), did not disappear entirely until the European genera had become developed so as to occupy an important place in the vegetation.

About this period (that is to say, after the Tongrian) the new revolution seems to have been completely achieved; the various groups of the vegetable kingdom occur in Europe combined pretty nearly as they are in the most favoured subtropical regions of the existing world.

The richness of this vegetation, of which the flora of Armissan and subsequently that of Œningen furnish us two magnificent specimens, is very great. We must not, however, conclude from it that the vegetable forms of the whole world were then united in Europe—though the Europe of that period would have no occasion to envy the most luxuriant of existing countries. Latitude as yet exerted its influence only in a feeble manner. The palms, which were very numerous in southern Europe along the shores of that sea of the Mollasse which cut through its centre, became less numerous to the north of that sea; the Laurineæ, which were there very abundant, penetrated to the neighbourhood in which the Baltic now exists, where a leaf of *Cinnamomum* has been found in a piece of amber; Cupressineæ, probably of the genus *Thujopsis*, of which this substance was the resin, formed beyond, in conjunction with pines, vast forests; further still

* We must insist upon this double fact, which is so conclusively proved by the organic evolution of the vegetable types which seem at present reciprocally to exclude each other: the pines and cedars, Coniferæ now proper to the boreal zone, appear in Europe from Secondary times in the midst of *Araucariæ*, Proteaceæ, and forms of Cycadeæ which are no longer observed except in the southern hemisphere; on the other hand, these latter types do not finally quit our soil until the Tertiary epoch is already far advanced. Thus the existing boreal types made their appearance in the midst of vegetation to a great extent Australian, and the Australian types disappeared from our zone only when the European vegetation had already acquired the physiognomy which distinguishes it. It is therefore only in the course of long periods that the various vegetable communities have been constituted and differentiated by the progressive development of their characteristic elements, and the slow elimination of those which have become foreign to them.

towards the north, Iceland and Greenland possessed not only pines and birches, poplars, willows, oaks, and alders, but also *Sequoiæ* and *Salisburiæ*, elms, hornbeams, figs, *Magnoliæ*, *Liriodendra* and vines, the analogues of which cannot now be found nearer than at least 12° more towards the south: these organisms required, in order to fructify and propagate, a mean temperature which M. Heer estimates at not less than 9°·5 C. (=49° F.). Even beyond the Polar circle, at Spitzbergen, about 79° N. lat., the Tertiary vegetation, according to the same author, still included hazels, hornbeams, and planes; and this vegetation was probably continued to the Pole itself.

Such was Europe in the Miocene age; only at the end of this period, in consequence of phenomena of which we are ignorant, or perhaps by the action of several combined causes, the temperature tended to diminish: this decrease, when once well marked, continued until the glacial times, when the cold, exceeding that of the present period, drove from our soil the greater part of the plants which previously ornamented it, and which, but for this circumstance, would have remained upon it, at least in part, and would have still subsisted there—our climate, in consequence of a fresh change, having subsequently been tempered.

L.—*On the Occurrence of* Ichthyosaurus *and* Plesiosaurus *in Australia.* By Frederick M'Coy, Professor of Natural Science in the University of Melbourne, and Director of the National Museum of Victoria.

To the Editors of the Annals of Natural History.

Gentlemen,

Referring to my paper in your Journal for November 1865, on the discovery of Cretaceous fossils in Central Australia, I have now the great pleasure of announcing the important fact that additional specimens have been received from Messrs. Carson and Sutherland, from the same locality, on the head of the Flinders River, enabling me to demonstrate the existence of Enaliosaurian reptiles in continental Australia during the period of Mesozoic deposits, which most geologists suppose not to occur in Australia. The remains are of the two well-marked genera *Ichthyosaurus* and *Plesiosaurus*. Of the former there are numerous vertebræ, deeply biconcave with conical articular surfaces, the centrum 4 inches wide, 3 inches deep, and 1½ inch long. The species I name *Ichthyosaurus australis* (M'Coy).

One of the species of *Plesiosaurus* has a slight resemblance to the New Zealand species noticed by Professor Owen, but is